PERFORMANCE ANALYSIS OF HEAVY EARTH MOVING MACHINERIES (HEMM) IN OPENCAST COAL MINES

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

THE DEGREE OF

BACHELOR IN TECHNOLOGY

IN

MINING ENGINEERING
BY

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DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLGY

ROURKELA-769008

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UNDER THE GUIDANCE OF

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CERTIFICATE

This is to certify that the thesis entitled **"PERFORMANCE ANALYSIS OF HEAVY EARTH MOVING MACHINERIES (HEMM) IN OPENCAST COAL MINES"** submitted by **Sri Shakti Namata** in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date:

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I have immense pleasure in successful completion of this project titled: **“PERFORMANCE ANALYSIS OF HEAVY EARTH MOVING MACHINERIES (HEMM) IN OPENCAST COAL MINES”** .This project has been a very good experience for me in the sense that it has given me some idea about the machines used in surface mines or in opencast mines.

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CONTENT

ABSTRACT

Open cast mining in the today's world has cyclic reappearance with prominent role in to mining sphere. Now-a-days the extent of mineral own by open cast mining is increases from year to year. This is due to the rapid strides made in the field of manufacture of open pit machinery. There has been a design explosion in the field of machinery, which have grown into enormous sizes with production capacities hitherto unimagined.

The major part of initial capital investment in any opencast mining goes towards the transportation and excavation equipment, their objective is to get maximum return per unit of investment. Time loss in operation due to idleness, breakdown of machine is no more affordable to mine management in recent years. Improper utilization of HEMMs have negative consequences on the production, productivity and production cost leading to loss of revenue. So it is important to analyses the performance of those equipment, at regular intervals to achieve cost- effectiveness in excavation and transportation operations.

An attempt has been made in this project to calculate the percentage availability and utilization of shovel, dumpers and dozer and other HEMMs deployed in an opencast mine of Gopinathpur mine ,Mugma area, Eastern Coalfield Limited & Jeenagora mine , Lodna area Bharat Coking Coalfield Limited and to analyses the contributing factors to improve the overall equipment performance.

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Chapter 1

INTRODUCTION

1.1 INTRODUCTION

Opencast mining is coming up on a large scale in the mechanized form in India. Because development in the field of mining machinery manufacture is yet in early stage development either in design complexity or in size, the open pit mines have to depend on imported equipment to a considerable extent. Here, some questions arises whether the existing heavy earth moving machinery- the backbone and largely depends on it open pit mechanization and representing such heavy capital investments- are being properly utilized .Are lessons from their performances in past being learnt?

As we know mining involves very costly and highly automated equipment for extraction of minerals, the size of the equipment and capacity has increased many folds in the recent past resulting in poor utilization and inefficiency of the machines. Mining managers are focused on effective utilization of the equipment so as to get early returns on their investments. Negligence in the area maintenance of the equipment used in mines is the area of concern and the management also did not give it much importance. Some study also reveals that the maintenance cost of the opencast mining equipment varies from 30-50% of the total operational cost in mechanized mine.

The overall culture in the organization needs to be addressed by changing the mindset of the employees that I operate you maintain it. It is the responsibility of the organization to determine the best method for the maintenance and operation the equipment and upkeep of the equipment.

It is now important to reduce the unscheduled and unplanned down time by making use of the suitable preventive maintenance measures.

If the maintenance is not carried up to the adequate level, the mining machines can result into lower speed of operation, premature failure, and reduced capacity or even can demand replacement of the costly equipment. So, it is not advisable to keep the standby equipment due to high procurement cost.

1.2 OBJECTIVES OF THE PROJECT

- To carryout performance appraisal of different HEMMs used in opencast coal mines of Gopinathpur mine, Mugma area, Eastern Coalfield Limited & Jeenagora mine, Lodna area Bharat Coking Coalfield Limited.
- To calculate percentage availability and utilization of HEMMs and determine their OEE (overall equipment effectiveness).

Chapter 2

LITERATURE REVIEW

2.1 OVERVIEW

Equipment Performance

There are different ways in which performance of the machine or equipment can be defined. The performance of the equipment and its effective use are greatly and directly related to the cost of production and productivity. Poor utilization of HEMMs and their consequences have a significant effect on the mineral production, productivity and cost of production. Poor utilization of any HEMM such as shovel, dumper, dozer etc during the working shift will lead to inevitable stoppage of production which will result in loss of revenue .The factor that's listed below are usually represented as standard for comparison for measuring the performance of the equipments following **[1].**

- **Productivity**

Productivity is defined as the output of the equipment per unit time. Some time the productivity of the equipment also terms as hourly production, daily production, monthly production and yearly production. All these values must be taken as the average of production over a period of time **[1].**

- **Cost per ton of material handled / excavated**

Due to competitive market scenario, the cost of production becomes an important factor while considering the economics of the mining project. The cost per ton of material handled/won includes the owning cost of equipment, which includes the depreciation, interest on capital etc., and the operating cost, which includes the cost on maintenance, energy and the labor **[1].**

- **Useful life of the equipment**

It is established that most repairable HEMM exhibit a "bath tub curve". It characterizes three phases of failure rates i.e. Decreasing Failure Rate (DFR) during early period of life or infant mortality period, Constant Failure Rate (CFR) during most parts of useful life of equipment and Increasing Failure Rate (IF) during aging or wear out life of equipment .It is necessary to discard the machine once it crossed the useful lifetime, since the operation during wear out life of equipment will not be economical. This parameter is very important since this will affect the return on investment **[1].**

2.2 FACTORS INFLUENCING THE PERFORMANCE

The following factors influence the performance of the equipment. They can be classified into two main headings that are controllable and non controllable factors. The geological conditions and environmental factors like monsoon comes under non controllable factors. The design aspects, efficiency of maintenance management, effectiveness of mine scheduling, skills and motivation imparted to the machine operators etc are discuss under the controllable factors **[1].**

- **Design factors**

The performance of the equipments is largely depends on the availability of the equipment which in turn depends on its which is include as a part of reliability feature. It is a performance barometer of overall machine conditions and an integral part of an engineering design. It can be increased by design effort and / or addition of quality material or modification **[1].**

- **Maintenance factors**

The elimination or the minimization the number of failures and the machine downtime is important and it can be done by proper maintenance. Necessary workshop facilities, skilled maintenance crew and proper tools need to be available. Efficient spare parts management is a must **[1].**

- **Managerial factors**

A mine must have sound management organization, which will draw sound plans for profitably utilizing the equipment. An important prerequisite is the availability of sufficient maintenance record of good quality. Indeed maintenance and utilization records need no longer be perceived as costly overhead, but as a strategic tool to maximize asset utilization **[1].**

- **Operational factors**

The productivity of the equipment lies in the hands of the operator. Only the skilful and efficient operator obtains reduction in the cycle time and high productivity. Proper motivation and training are essential to achieve the same **[1].**

- **Environmental factors**

The environmental factors like monsoons, the geological conditions of the deposit also affect the machine productivity to a greater extent **[1].**

2.3 MEASURES TO IMPROVE THE PERFORMANCE OF HEMMS

The following steps can be taken to improve the performance of equipment **[1].**

- Maintaining reliable maintenance and utilization records.
- Redesign of machine components to have high reliability and ease of access and maintenance.
- Having proper maintenance facilities, skilled workmen, maintenance schedule, communication system between mine and workshop.
- Analyzing the important causes of high frequency of failures, delay in repair, idle time and take necessary actions to improve asset availability and utilization.
- Incorporating fault diagnosing elements to reduce the time spent in falt diagnosing and thereby decreases the machine down time.
- Providing quality training to the machine operators and maintenance personnel.
- Giving motivation to machine operators by effective incentive schemes.
- Ensuring efficient spare parts management system **[1].**

2.4 DESCRIPTION ABOUT HEMMS USED IN MINES:

General description of the HEMMs that are used in the two visited mine are as follow:-

- **Dozers:-**

A dozer is a continuous tracked tractor (crawler) with a blade (substantial metal plate) used to push large quantities of soil, sand, rubble, or other such material during constructions or conversion work and typically equipped at the rear with a claw-like device called ripper to loosen densely compacted materials. The tracks of the dozer give them excellent ground holding capability and mobility through very rough terrain. Wide tracks of the dozer helps to distribute its weight over a large area and decreasing the ground pressure thus prevent it from sinking in muddy or sandy ground. Extra wide tracks are known as swamp tracks or LGP (low ground pressure) tracks. Bulldozers have transmission systems designed to take advantage of the track system and provide excellent tractive force **[3].**

Blade:

The blades of a dozer are a heavy metal plate on the front side of the tractor, used to push objects, and shove sand soil and debris. Dozer blades are usually three types **[7]**:-

1. A straight blade ("S blade") which is short and has no lateral curve and no side wings and can be used for fine grading.

2. A universal blade ("U blade") which is tall and much curved, and has large side wings to carry more material.

3. An "S-U" combination blade which is shorter has less curvature, and smaller side wings. This blade is typically used for pushing piles of large rocks, such as at a quarry. Blades can be fitted straight across the frame, or at an angle, sometimes using additional 'tilt cylinders' to vary the angle while moving. The bottom edge of the blade can be sharpened, e.g. to cut tree stumps **[7].**

Ripper

The ripper is the long claw-like device on the back of the bulldozer. Rippers can come as a single (single shank/giant ripper) or in groups of two or more (multi shank rippers). Usually, a single shank is preferred for heavy ripping. The ripper shank is fitted with a replaceable Tungsten steel alloy tip**.** Ripping rock breaks the ground surface rock or pavement into small rubble easy to handle and transport, which can then be removed so grading can take place. With agricultural ripping, a farmer breaks up rocky or very hard earth (such as podzol hardpan), which is otherwise un-plough able, in order to farm it. For example, much of the best land in the California wine country consists of old Lava flows **[7].**

Fig.2.1 Dozer (Caterpillar)

- ## Drills:

The drills that are used in opencast mine are either hydraulic or pneumatic operated to make hole on the rock or ground. It is also called drifter. The feed is like a rail that the drill travels on, aka. drifts. This kind of drilling procedure is also called drifting. The feed is usually attached with a flexible boom (like an arm) to a stationery or mobile unit that contains the powerpack (engine and hyd. pump or compressor)**.**A hydraulic operated drill is usually consists of percussive system and rotative system. The percussive system strikes the drill steel, for example 2000-5000 strikes per minute as the rotation can be, for example, 100-400 rounds per minute. Combined together, these functions enable drilling holes into rock. The excess material (cuttings) is then pushed up from the bottom of the hole by means of pressurized air or water **[8].**

The Down-the-hole drill is an example of pneumatically operated drills. The down-the-hole drill is basically a mini jack hammer that screws on the bottom of a drill string. DTH is short for “down-the-hole”. Since the DTH method was originally developed to drill large-diameter holes downwards in surface-drilling applications, its name originated from the fact that the percussion mechanism followed the bit down into the hole. Applications were later found for the DTH method underground, where the direction of drilling is generally upwards instead of downwards. The fast hammer action breaks hard rock into small flakes and dust and is blown clear by the air exhaust from the DTH hammer. The DTH hammer is one of the fastest ways to drill hard rock. Now, smaller portable drill cat drilling rigs with DTH hammers can drill as fast as much larger truck rigs with this newer technology **[8].**

Fig.2.2 Drills (Atlascapso)

- ## Dumper :-

A dumper or dump truck is a truck used for transporting loose material such as coal ,ore ,overburden ,top soil for mining and sand, gravels, or soil for constructions. A typical dump truck is equipped with an open-box bed, which is hinged at the rear and equipped with hydraulic piston to lift the front, allowing the material in the bed to be deposited ("dumped") on the ground behind the truck at the site of delivery **[9].**

A standard dump truck is a truck chassis with a dump body mounted to the chassis. The bed is raised by a vertical hydraulic ram mounted under the front of the body, or a horizontal hydraulic ram and lever arrangement between the frame rails, and the back of the bed is hinged at the back of the truck. The tailgate can be configured to swing up on top hinges (and sometimes also to fold down on lower hinges) or it can be configured in the "High Lift Tailgate" format wherein pneumatic rams lift the gate open and up above the dump body **[9].**

In the United States, a standard dump truck has one front steering axle, and one or two rear axles which typically have dual wheels on each side. Tandem rear axles are virtually always powered in the U.S., far less often in Europe. Most unpowered rear axles can be raised off the pavement, to minimize wear and tear when the truck is empty or lightly loaded, and lowered to become load-bearing when the truck needs the extra support. These are referred to as lift axles or drop axles. Lift axles can be steerable or non-steerable; steerable lift axles are always configured with single wheels on each side, instead of dual wheels. Lift axles positioned in front of the powered axles are called pushers; lift axles positioned behind the powered axles are called tags **[9].**

The dumpers that are used in opencast mines have a rigid frame and conventional steering with drive at the rear wheel. As of late 2013, the largest ever production haul truck is the 450 metric tons Be1AZ 75710, followed by the Liebherr T 282B, the Bucyrus MT6300AC and the Caterpillar 797F which each have payload capacities of up to 400 short ton (363 Tonne; 357 Long ton). Most large size haul trucks employ Diesel-electric power trains, using the Diesel engine to drive an AC alternator or DC generator that sends electric power to electric motors at each rear wheel. The Caterpillar 797 is unique for its size, as it employs a Diesel engine to power a mechanical power train, typical of most road going vehicles and intermediary size haul trucks. Other major manufacturers of haul trucks include Hitachi, Beml , Komatsu, DAC, Terex and Be1AZ **[9].**

Fig.2.3 Dumper (BEML 60M, 100)

- ## Shovel:-

A shovel is a equipment which excavates the rock or ore by digging from the operating base to upwards and dump it either on an dumper or railway wagon or over the spoil dump for backfilling after swing itself within its limits .It is highly productive machine and capable of handle all types of ores ,rock ranging from fine to very hard blocky lump has lower operating cost higher production and productivity etc. It requires lower power and has less wire rope cost .I also required less manpower to operates and needs less surface preparation .It can also load in various mining condition, has longer life higher availability and can also do production by staying in the inclined terrain **[10].**

However ,it has low maneuverability ,low flexibility, effected by climate and watery condition ,bank slides etc .Shovel is used for digging a deeper cut ,loading and overcastting and pull backing the spoil material, overburden removal in opencast mining .

The bucket which is mounted with sharp teeth cut the rock or mineral body and break them with the help of pressure provided by the hoist and crowd actions **[10].**

Shovel can be broadly divided into two categories:-

- **Rope shovel,**
- **Hydraulic shovel.**

Rope shovel:-

It s a bucket-equipped machine, usually electrically powered, used for digging and loading earth or fragmented rock and for mineral extraction .It is also called Power shovel, electric shovel etc.

Shovels normally consist of a revolving deck with a power plant, driving and controlling mechanisms, usually a counterweight, and a front attachment, such as a crane or boom, which supports a handle dipper or dipper stick with a digger bucket at the end. Dipper is also sometimes used to refer to the handle and digger combined. The machinery is mounted on a base platform with tracks or wheels. Modern bucket capacities range from 8 m^3 to nearly 80 m^3.

Power shovels are used principally for excavation and removal of overburden in opencast mining operations, though it may include loading of minerals, such as coal. They are the modern equivalent of steam shovel, and operate in a similar fashion **[10].**

The shovel operates using several main motions:-

- Hoist- pulling the bucket up through the bank (i.e. the bank of material being dug).
- Crowd- moving the dipper handle out or in to control the depth of cut and when positioning to dump.
- Swing- rotating the shovel between digging and dumping.
- Propel- moving the shovel unit to different locations or dig positions.

A shovel's work cycle, or digging cycle, consists of four phases:

- Digging
- Swinging
- Dumping
- Returning.

The digging phase consists of crowding the dipper into the bank, hoisting the dipper to fill it, then retracting the full dipper from the bank. The swinging phase occurs once the dipper is clear of the bank both vertically and horizontally. The operator controls the dipper through a planned swing path and dump height until it is suitably positioned over the haul unit (e.g. truck). Dumping involves opening the dipper door to dump the load, while maintaining the correct dump height. Returning is when the dipper swings back to the bank, and involves lowering the dipper into the tuck position to close the dipper door **[10].**

Hydraulic shovel:-

The hydraulic shovel is hydraulically operated and most commonly used for digging rocks and soil, but with its many attachments it can also be used for cutting steel, breaking , holes in the earth, laying gravel onto the road prior to , crushing rocks, steel, and concrete, and even mowing landscapes. Hydraulic excavators have an operating weight of 20,000 pounds (9,072 kg) or higher **[10].**

Some of the features of the hydraulic shovels are:

The Arm:-The hydraulic excavator operates on different levels. The first is the arm of the vehicle. The arm is comprised of two hydraulic cylinders, a bucket and a boom, which is on the upper part of the arm. The arm moves in two parts just like a human arm would: at the wrist and the elbow.

Inside of the hydraulic cylinder is a rod, which is the inner part of the cylinder, and a piston, which is at the end of the cylinder and enables the arm to move with the help of oil. If there were no oil in the cylinder, the piston would drop to the bottom, but because of the nature of oil, its volume always stays the same **[10].**

Oil is pumped through the end of the piston and in turn pushes the rod through the cylinder, thus creating movement of one or both parts of the arm. By controlling the amount of oil is pumped through the valve, the accuracy of the arm can be easily manipulated. This movement is activated by the use of control valves that are positioned inside the cab where the driver seat is.

The Engine:-Power in an automobile is normally received straight from the engine but it works differently in a hydraulic excavator. Because the machine uses a lot of force, it is able to move by changing the energy it receives from the engine into hydraulic power **[10].**

The Swing:-One of the functions of this machine is its ability to turn. The swing of the excavator enables it to turn. The swing circle comprises of several components: an outer race, an inner race, ball bearings and a pinion. As the outer race turns, the pinion runs alongside the unmoving inner race. The ball bearings work to ensure that this is done smoothly **[10].**

The Cab:-The third part of the hydraulic excavator is the upper structure where the driver's seat is located and the controls are positioned. With the help of two levers on both side and two in the front, the driver can move both at the same time to control direction and height **[10].**

Fig.2.4 Rope and hydraulic shovel (Caterpillar , P&H)

2.5 MINING EQUIPMENT INDUSTRY IN INDIA

➢ History and Background

Opencast mining equipment in India uses large variety of machineries for example dozers, scrapers, dumpers ,rope shovel, drills ,hydraulic excavators, wheel loaders, backhoe loaders, bull dozers ,graders etc **[12].**

They usually do various task such as preparation of haulage of material, dumping/laying in specified manner ,ground, excavation, material handling, road construction etc.

Perhaps, India is the only developing country, which is totally self-reliant in this kind highly sophisticated equipment with high production capacity. There are few medium and large companies in the organized sector in India who manufacture these equipments with high technology barriers **[12].**

Domestic production began in 1964 with the setting up of Bharat Earthmovers Ltd. (BEML), a public sector unit of the Ministry of Defense, at Kolar in South India to manufacture dozers, dumpers, graders, scrapers, etc. for defense requirements under license from Letourneau Westinghouse, USA and Komatsu, Japan **[12].**

In the private sector, the Hindustan Motors’ Earthmoving Equipment Division, was established in 1969 at Tiruvallur, near Chennai with technical collaboration from Terex, UK for manufacture of wheel loaders, dozers & dumpers. This factory has since been taken over by Caterpillar for their Indian operations. The machines manufactured by Caterpillar in the Tiruvallur factory are marketed by TIL and GMMCO **[12].**

In 1974, L&T started manufacturing hydraulic excavators under license from Poclain, France. In 1980 and 1981, two more units, Telcon and Escorts JCB commenced manufacture of hydraulic excavators (under license from Hitachi, Japan) and backhoe loaders (under license from JCB, UK) respectively. Escorts JCB has been taken over by JC Bamford Excavators Ltd. U.K. in 2003 and is now called JCB India Ltd. Terex Vectra and Volvo are the latest entrants to the Indian market. Volvo has set up their manufacturing unit in Bangalore. Most of the technology leaders like Case, Komatsu, John Deere, Caterpillar, Hitachi, Ingersoll-Rand, JCB, Joy Mining Machinery, Lieberr, Poclain, Terex, Volvo are present in India as joint venture companies, or have set up their own manufacturing facilities, or marketing companies. The industry has made substantial investments in the recent past for setting up manufacturing bases, despite small volumes and uneconomic scales of production compared to global standards **[12].**

- ## List of mining equipments and their current status

The growth in this sector is interconnected with the growth of the Indian economy and indirectly with the growth of infrastructure from evidence of the graph below [12].

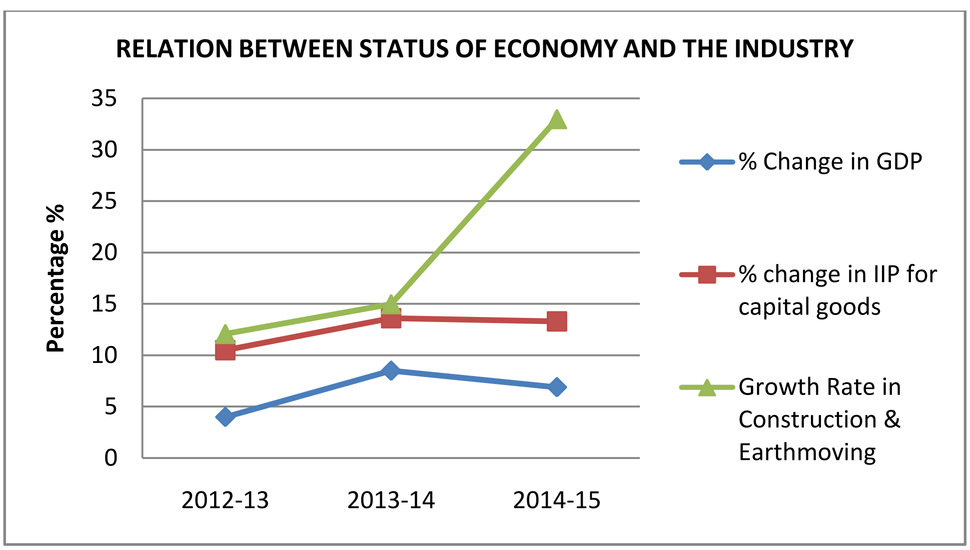

Fig.2.5 Relation between status of economy and the industry

The mining equipment industry is dominated by a few large manufacturers in each product segment. BEML supplies to nearly half the total market. BEML & Caterpillar lead in dumpers and dozers while L&T-Komatsu and Telcon lead in excavators and JCB India in backhoe loaders **[12].**

TABLE.2.1 List of Earthmoving Machineries Company [12]

Products	**Companies**
EARTHMOVING MACHINERIES	Bharat Earth Movers Limited
	L&T Komatsu
	Larsen & Toubro
	Telcon
	Ingersoll-Rand (India)
	Hyderabad Industries
	A C C Machinery Co.
	Greaves Cotton
	Voltas
	Tata Motors
	Viraj Technocom
	T R F
	Bemco Jacks & Allied Products
	Tractor Engineers
	Texmaco
	Tata Motors
	Southern Structurals
	Marshall Sons & Co. (Mfg.)
	Hindustan Motors
	Garden Reach Shipbuilders & Engineers
	Escorts JCB

2.6 DATA REQUIRED FOR PERFORMANCE ANALYSIS

For a proper analysis of the performance of equipment one must keep proper and up- to-date records regarding the following **[2].**

- **Calendar Hours (CH)**

This means the total number of hours during the period of observation. It is equal to

365 *24 = 8760 hours in a year **[2].**

- **Scheduled Shift Hours (SSH)**

This means number of hours, the mine employing the machinery is supposed to work in a year. This is a management decision after giving due consideration to the type of mineral mined, the ore reserves, the output of mineral, capital investment involved, market conditions, labor conditions etc. The higher the capital investment, the higher should be the figure for scheduled-shift – hours. In advanced countries very large equipment work round the clock.

In India, the general tendency is to work for 16 hours a day and six days a week. In the mine under consideration, the equipment are planned to work for two shifts of six hours each. So the scheduled shift hours are 12 hours per day **[2].**

- **Maintenance Hours (MH)**

It is the time or total hours given to the machine for its maintenance and repair purpose if the machine have some sort of breakdown due failure of some part of the machines **[2].**

- **Breakdown Hours (BH)**

It is the total hours of the equipment working in the mines for which it remain in breakdown > condition **[2].**

- **Idle Hours (IH)**

It is the time loss of the equipment for the activity like drilling, blasting, cable shifting, raining, and time taken to get the spare part of the equipment in case of breakdown **[2].**

2.7 FACTORS AND INDICES TO BE CALCULATED FOR PERFORMANCE ANALYSIS

From the basic information or data collected, as above SSH, MH, BH, ID, the availability and utilization percentage on schedule-shit-hours basis a, production efficiency and overall equipment efficiency can be determined. In the following paragraphs these factors and indices have been defined and their importance brought out **[2].**

- **Percentage Availability (A)**

  It is the ratio of total available working hours to the total hours the equipment supposed to be work **[2].**

$$\text{Percentage Availability (A)} = \frac{SSH - BH - MH}{SSH} \text{ x } 100 \quad (1)$$

- **Percentage Utilization (U)**

This is defined as the ratio of the time in hours the machine is actually used in a year to the total hours [2].

$$\text{Percentage Utilization (U)} = \frac{SSH - MH - BH - IH}{SSH} \text{ x } 100 \quad (2)$$

Where SSH-schedule shift hours, MH-maintenance hours, BH-breaking-down Hours

IH- Idle Hours **[2].**

- **Overall Equipment Effectiveness (OEE)**

OEE is a simple tool that will help to measure the effectiveness of their equipment. It takes the most common and important sources of productivity loss, which are called six big losses and given in Table 2.9 These losses, are quantified as availability, performance and quality in order to estimate OEE **[13].**

$$OEE = \text{Availability} \times \text{Performance} \times \text{Quality} \quad (3)$$

- **Major Loss event and Affected OEE**

TABLE.2.2: Loss events and its effects [13]

Factors for Loss Category	**OEE Factors**	**Loss Category**
Equipment failure.	Availability	Down-Time Loss
Maintenance.		
Machine warm Up.		
Material Shortage.		
Machine Changeovers.		
Over aging of Equipment.	Performance	Speed Loss
Operator Training Level.		
Idling and Minor stoppages		
Job Conditions like snow, dust, fog etc.		
Operator Inefficiency.		
Equipment Standby.	Quality	Defect Loss
Assembled Incorrectly.		
Quality Defects		

Availability (A):

A machine is considered available when it is fit to be put to perform its duties. The availability is determined by dividing the hours the machine is available and is used plus the hours it is available but not used due to various reasons over a period of one year. It is normally expressed in percentages. Number of scheduled-shift-hours in a year for equipment operation is taken as total shift hours. Overtime hours of work if any are added to the total shift hours. Stoppage of less than 15 minutes is ignored and the machine is taken as having been used during that period **[13].**

Percentage availability helps in judging and comparing the efficiency of the maintenance departments of different units. This can also assist the management in knowing how the availability of machine would change by changing the scheduled shift hours of work. Percentage availability of machine would change by changing the scheduled shift hours of work **[13].**

$$\text{Availability} = \frac{\text{Net Available Time} - \text{Downtime Loss}}{\text{Net Available Time}} \times 100 \qquad (4)$$

Performance:

Performance takes into account Speed Loss, which includes any factors that cause the process to operate at less than the maximum possible speed, when running. Examples include machine 22 wear, substandard materials, mis-feeds, and operator inefficiency. The remaining available time is called Net Operating Time **[13].**

$$\text{Performance} = \frac{\text{Operating Time} - \text{Speed Loss}}{\text{Operating Time}} \times 100 \qquad (5)$$

Quality:

Quality takes into account Quality Loss, which accounts for produced pieces that do not meet quality standards, including pieces that require rework. The remaining time is called fully Productive Time. Our goal is to maximize Fully Productive Time **[13].**

$$\text{Quality} = \frac{\text{Net Operating Time} - \text{Defect Loss}}{\text{Net Operating Time}} \times 100 \qquad (6)$$

Chapter 3

DATA COLLECTION, CALCULATION AND ANALYSIS

AND PERFORMANCE ANALYSIS OF HEMM IN OPENCAST COAL MINES

3.1 METHODOLOGY

- In order to satisfy the above stated objectives, data has been collected from two different mines that's are Gopinathpur mine, Mugma Area, Eastern Coalfield Limited (ECL) & Jeenagora mine, Lodna Area, Bharat Coking Coal Limited (BCCL).
- Data of working hours (WH), maintenance hours (MH), breakdown hour (BH), idle hours (IH) were collected from the above mentioned mine during (2014-15).
- Percentage availability and percentage utilization were calculated from the above collected data for all the HEMMs present there i.e. shovel, dumpers, dozers, drills.
- Overall Equipment Effectiveness (OEE) was calculated for the shovel of the two mine mentioned above.
- OEE, percentage availability and percentage utilization were compared for the two mines.

3.2 PERFORMANCE OF THE HEMMS IN GOPINATHPUR MINE (2014-15)

TABLE.3.1: Working Hours (2014-15)

Eqpt	Model		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Shovel	EX350	488	324	268	327	201	141	84	228	224	326	178	198	0	2499
	H55N	55011	0	0	0	0	29	101	1	45	38	132	86	0	432
	EX300	824	39	100		97	82	124	51	13	133	142	127	0	908
	CK300	733	312	200	337	271	275	257	266	342	384	347	338	0	3329
			675	568	664	569	527	566	546	624	881	799	749	0	7168
Dozer	BD-155	13116	175	176	210	183	163	188	173	259	250	213	196	0	2186
		847	22	0	0	0	0	0	0	0	0	0	0	0	22
		205	146	37	30	18	2	59	34	14	53	57	8	0	458
		12768	98	83	184	126	83	129	118	167	117	201	195	0	1501
		13307	39	238	249	211	238	222	229	253	241	264	274	0	2458
			480	534	673	538	486	598	554	693	661	735	673	0	6625
Dumper	BH35-2	882	6	0	40	109	44	55	36	5	93	101	118	0	607
		1384	331	243	360	269	258	244	225	354	378	319	357	0	3338
		1394	247	183	238	153	126	112	247	325	306	284	315	0	2536
		1427	332	284	322	262	261	246	300	359	363	311	377	0	3417
		1428	297	320	263	218	266	240	300	344	324	300	304	0	3176
		1429	178	150	178	91	56	93	41	62	188	219	231	0	1487
			1391	1180	1401	1102	1011	990	1149	1449	1652	1534	1702	0	14561
Drill	ICM-260	4917	0	0	0	0	0	0	0	0	0	0	0	0	0
	ICM-260	75173	44	4	40	58	11	28	32	37	33	32	63	0	382
	IDM-30	605624	150	193	123	83	105	102	121	221	245	245	242	0	1838
			194	197	163	141	116	130	153	258	277	277	305	0	2220

TABLE.3.2: Breakdown Hours (2014-15)

Eqpt	Model		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Shovel	EX350	488	56	173	93	224	350	351	162	85	88	376	287	0	2245
	H55N	55011	744	696	744	720	627	395	622	573	545	145	361	0	6172
	EX300	824	117	146		207	78	118	60	390	34	37	27	0	1214
	CK300	733	61	271	19	22	18	0	59	47	25	21	88	0	631
			978	1286	856	1173	1073	864	903	1095	692	579	763	0	10262
Dozer	BD-155	13116	0	0	0	0	0	10	66	0	0	0	0	0	76
		847	616	696	744	0	0	0	0	0	0	0	0	0	2056
		205	298	0	0	0	0	20	23	35	23	55	6	0	460
		12768	168	144	0	0	72	52	0	0	12	0	59	0	507
		13307	299	79	72	0	0	0	4	182	66	29	126	0	857
			1381	919	816	0	72	82	93	217	101	84	191	0	3956
Dumper	BH35-2	882	4	0	0	0	0	12	0	0	6	14	12	0	48
		1384	35	41	0	24	9	49	132	20	40	91	3	0	444
		1394	4	0	24	3	23	26	3	0	44	8	8	0	143
		1427	0	0	69	14	0	20	34	3	45	90	69	0	344
		1428	58	0	127	150	26	35	3	0	50	96	120	0	665
		1429	0	0	0	25	0	16	544	460	100	4	0	0	1149
			101	41	220	216	58	158	716	483	283	303	212	0	2793
Drill	ICM-260	4917	744	696	744	720	720	720	624	744	720	744	720	0	7896
	ICM-260	75173	285	646	276	67	22	34	80	28	5	614	49	0	2106
	IDM-30	605624	283	160	162	48	132	91	346	70	91	179	116	0	1678
			1312	1502	1182	835	874	845	1050	842	816	1537	885	0	11680

TABLE.3.3: Maintenance Hours (2014-15)

Eqpt	Model		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Shovel	EX350	488	60	46	58	40	27	22	40	168	52	34	36	0	583
	H55N	55011	0	0	0	0	9	22	1	11	12	32	21	0	108
	EX300	824	18	30		16	19	33	13	5	22	25	24	0	205
	CK300	733	60	37	60	40	54	49	48	56	60	66	59	0	589
			138	113	118	96	109	126	102	240	146	157	140	0	1485
Dozer	BD-155	13116	35	35	39	43	38	38	36	46	48	48	43	0	449
		847	6	0	0	0	0	0	0	0	0	0	0	0	6
		205	30	8	12	7	1	22	13	5	20	23	2	0	143
		12768	12	9	37	35	24	31	32	44	41	48	40	0	353
		13307	16	47	55	53	54	52	48	57	56	57	56	0	551
			99	99	143	138	117	143	129	152	165	176	141	0	1502
Dumper	BH35-2	882	2	0	9	28	11	25	10	3	24	27	25	0	164
		1384	15	13	16	15	14	13	49	70	69	41	33	0	348
		1394	14	10	15	11	12	14	55	66	87	42	29	0	355
		1427	15	14	15	15	16	20	64	74	70	36	30	0	371
		1428	15	14	13	14	15	17	67	71	67	43	26	0	362
		1429	14	12	13	8	7	10	11	18	39	31	26	0	189
			75	63	81	91	75	99	256	302	356	222	169	0	1789
Drill	ICM-260	4917	0	0	0	0	0	0	0	0	0	0	0	0	0
	ICM-260	75173	23	3	22	26	5	16	12	16	14	10	20	0	167
	IDM-30	605624	41	43	34	21	28	24	23	51	53	47	47	0	412
					150	47	115	149	302	387	462	310	262	0	2369

TABLE.3.4: Idle Hours (2014-15)

Eqpt	Model		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Shovel	EX350	488	304	209	266	255	202	263	194	267	254	156	199	0	2569
	H55N	55011	0	0	0	0	55	202	0	115	125	435	252	0	1184
	EX300	824	570	420		128	220	157	228	8	27	292	46	0	2096
	CK300	733	311	188	328	387	373	414	251	299	251	310	235	0	3347
			1185	817	594	770	850	1036	673	689	657	1193	732	0	9196
Dozer	BD-155	13116	534	485	495	494	520	485	349	439	422	483	481	0	5187
		847	100	0	0	0	0	0	0	0	0	0	0	0	100
		205	271	651	702	423	398	331	282	362	120	361	208	0	4109
		12768	466	460	523	559	541	508	474	533	550	495	426	0	5535
		13307	142	331	368	456	442	446	344	252	357	394	264	0	3796
			1513	1927	2088	1932	1901	1770	1449	1586	1449	1733	1379	0	18727
Dumper	BH35-2	882	732	696	695	311	345	340	306	408	93	354	69	0	4349
		1384	363	399	368	412	439	414	218	300	233	293	327	0	3766
		1394	479	503	467	553	559	568	319	353	283	410	368	0	4862
		1427	397	398	338	429	443	435	226	308	242	305	244	0	3765
		1428	374	362	341	338	413	428	254	329	279	305	270	0	3693
		1429	552	534	553	596	657	600	28	204	393	490	463	0	5070
			2897	2892	2762	2639	2856	2785	1351	1902	1523	2157	1741	0	25505
Drill	ICM-260	4917	0	0	0	0	0	0	0	0	0	0	0	0	0
	ICM-260	75173	392	43	406	569	442	354	228	335	668	88	588	0	4113
	IDM-30	605624	270	300	425	568	454	504	134	402	323	273	315	0	3968
			662	343	831	1137	896	858	362	737	991	361	903	0	8081

TABLE.3.5: Percentage Availability (2014-15)

Eqpt	Model		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Shovel	EX350	488	84	69	80	63	48	48	68	66	81	45	55	0	64
	H55N	55011	0	0	0	0	12	42	0	22	23	76	47	0	20
	EX300	824	82	75	0	50	76	65	79	5	73	87	82	0	57
	CK300	733	84	56	89	91	90	93	83	86	88	88	80	0	84
Dozer	BD-155	13116	95	95	95	94	95	93	84	94	93	94	94	0	93
		847	16	0	0	0	0	0	0	0	0	0	0	0	1
		205	56	99	98	92	95	90	90	84	80	84	96	0	79
		12768	76	78	95	95	87	88	95	94	93	94	86	0	89
		13307	37	82	83	93	93	93	92	68	83	88	75	0	80
Dumper	BH35-2	882	99	100	99	58	54	82	82	99	39	92	83	0	81
		1384	93	92	98	95	97	91	71	88	85	82	95	0	90
		1394	98	99	95	98	95	94	91	91	82	93	95	0	94
		1427	98	98	89	96	98	95	84	90	84	83	86	0	91
		1428	90	98	81	77	94	93	89	90	84	81	80	0	87
		1429	98	98	98	95	99	97	11	54	81	95	96	0	84
Drill	ICM-260	4917	0	0	0	0	0	0	0	0	0	0	0	0	0
	ICM-260	75173	59	7	60	87	94	88	74	89	97	16	90	0	67
	IDM-30	605624	56	71	74	90	78	84	41	84	80	70	77	0	73

TABLE.3.6: Percentage Utilization (2014-15)

Eqpt	Model		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
Shovel	EX350	488	44	39	44	28	20	12	37	30	45	24	28	0	32
	H55N	55011	0	0	0	0	4	14	0	6	5	18	12	0	5
	EX300	824	5	14	0	22	21	29	15	3	60	26	66	0	21
	CK300	733	42	29	45	38	38	36	64	46	53	47	47	0	44
Dozer	BD-155	13116	24	25	28	25	23	26	28	35	35	27	27	0	28
		847	3	0	0	0	0	0	0	0	0	0	0	0	0
		205	20	5	4	4	0	14	10	3	25	4	4	0	7
		12768	13	12	18	18	12	18	19	22	16	27	27	0	19
		13307	8	34	29	29	32	31	37	34	33	38	38	0	31
Dumper	BH35-2	882	1	0	15	15	6	11	9	11	19	53	53	0	13
		1384	44	35	48	37	36	34	36	48	53	43	50	0	42
		1394	33	26	32	21	18	16	40	44	43	38	44	0	32
		1427	45	41	43	36	36	34	48	48	50	42	52	0	43
		1428	40	46	35	30	37	33	48	46	45	40	42	0	40
		1429	24	22	24	13	8	13	7	8	26	29	32	0	19
Drill	ICM-260	4917	0	0	0	0	0	0	0	0	0	0	0	0	0
	ICM-260	75173	6	1	5	8	2	6	8	7	5	4	9	0	6
	IDM-30	605624	20	28	17	12	15	14	19	30	35	33	34	0	23

3.3 PERCENTAGE AVAILABILITY AND PERCENTAGE UTILIZATION GRAPH OF THE HEMMS IN GOPINATHPUR MINE (2014-15)

- **For Shovel**

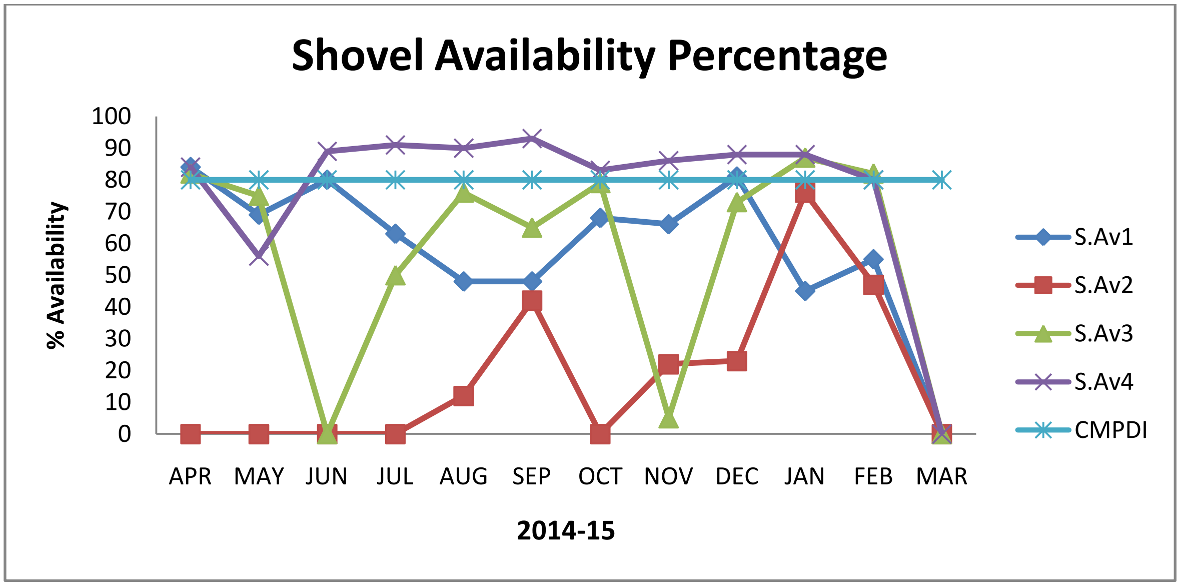

Fig.3.1 Availability Percentage of Shovel

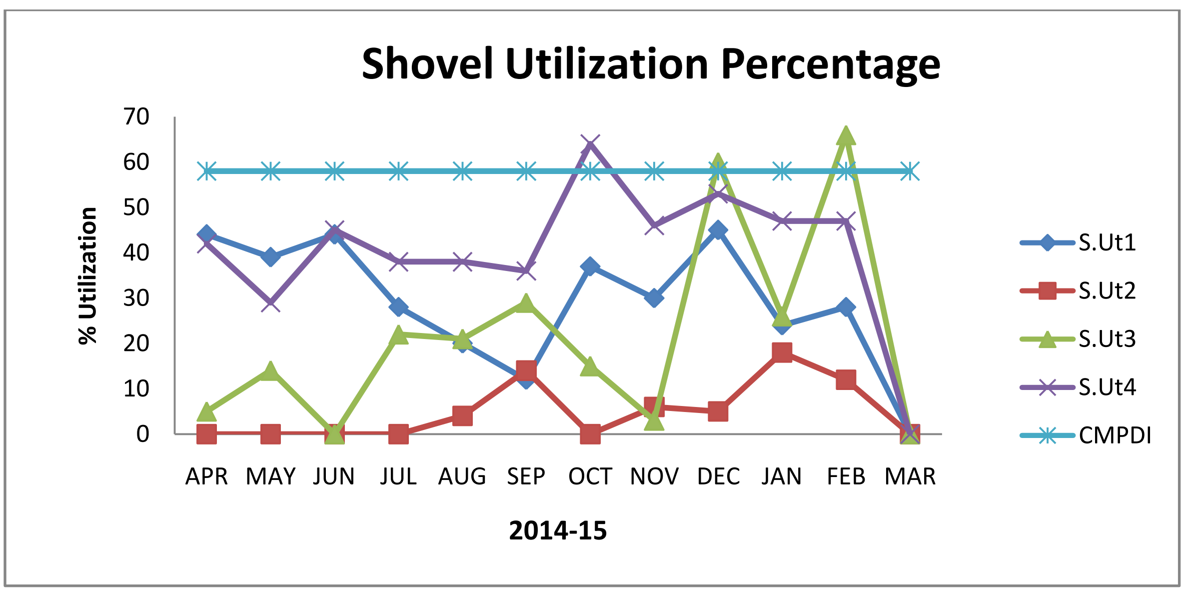

Fig.3.2 Utilization Percentage of Shovel

- **For Dumper**

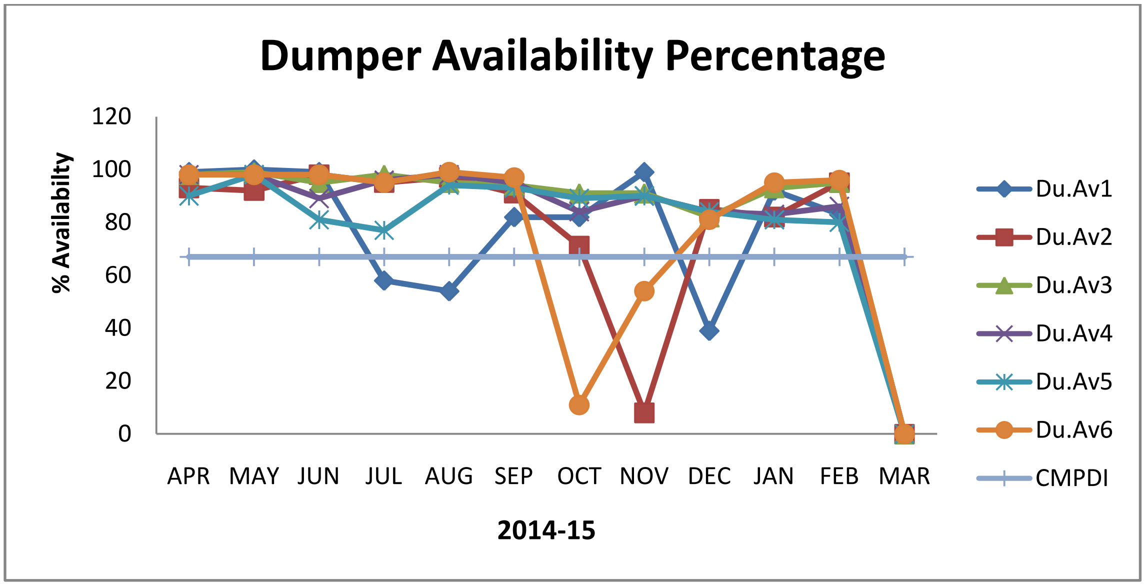

Fig.3.3 Availability Percentage of Dumper

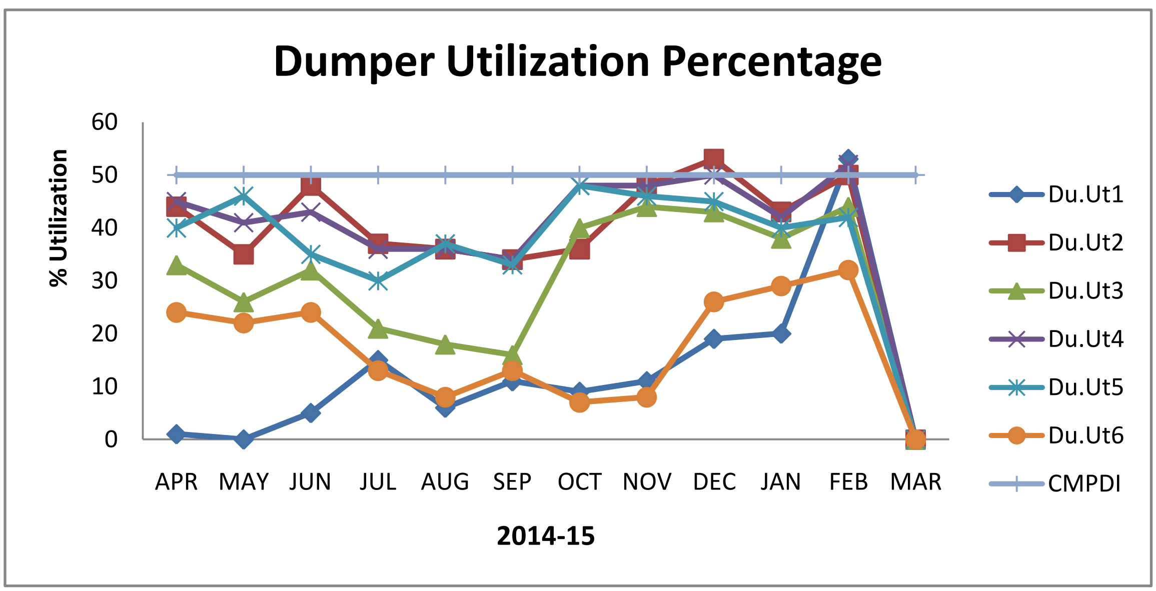

Fig.3.4 Utilization Percentage of Dumper

- **For Dozer**

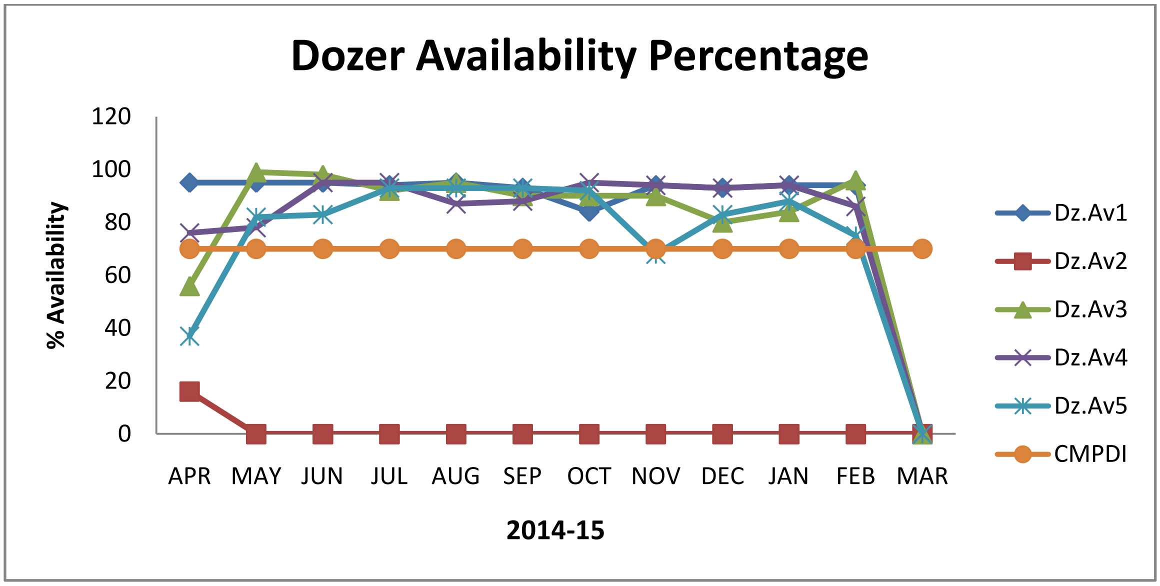

Fig3.5 Availability Percentage of Dozer

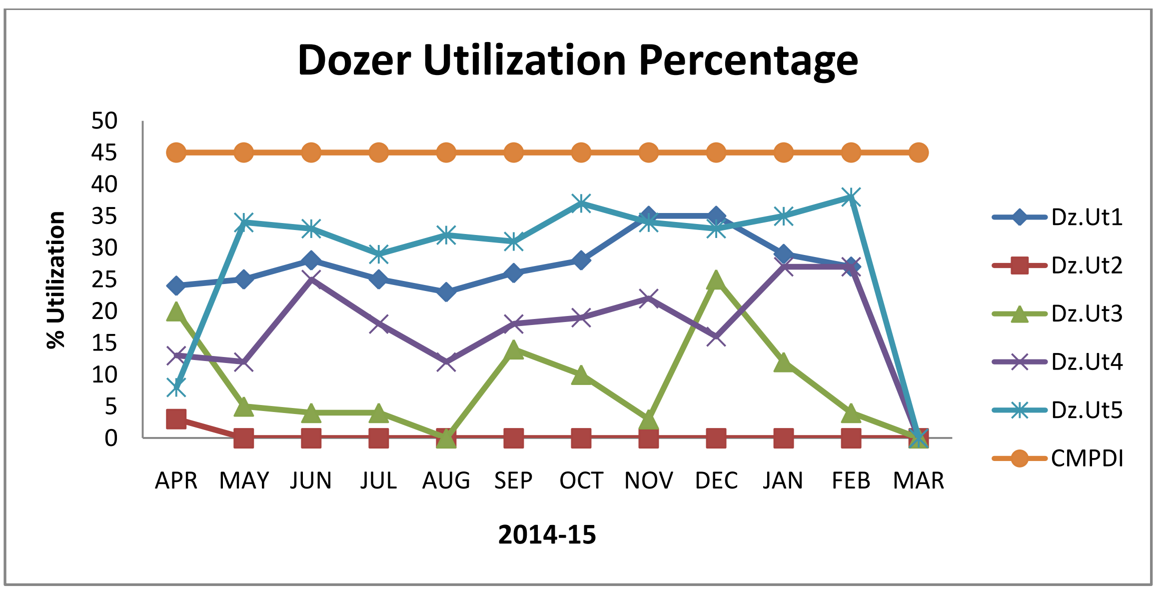

Fig.3.6 Utilization Percentage of Dozer

➢ **For Drill**

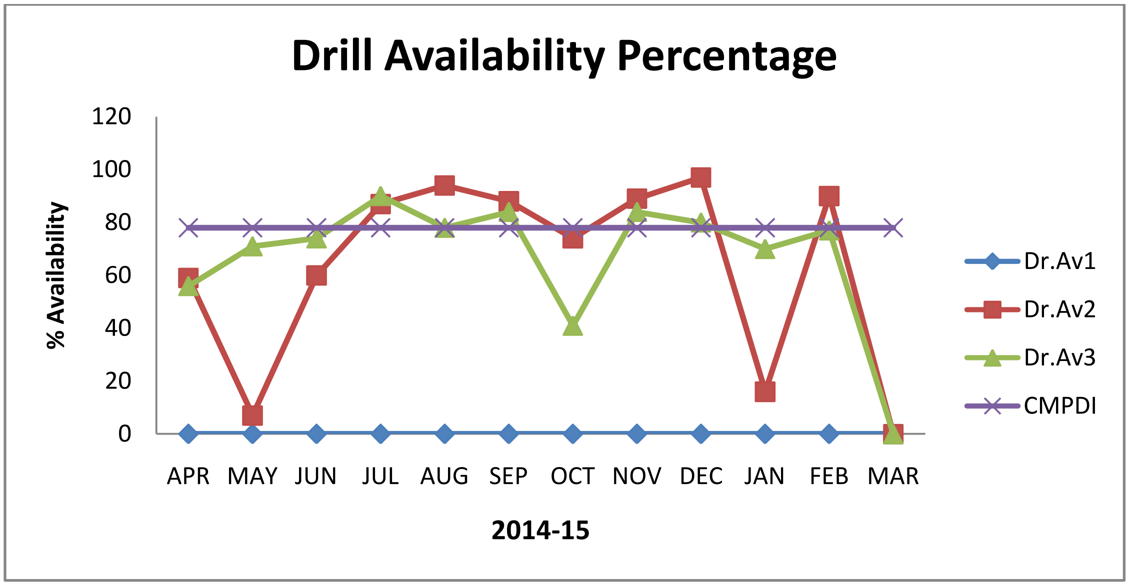

Fig.3.7 Availability Percentage of Drill

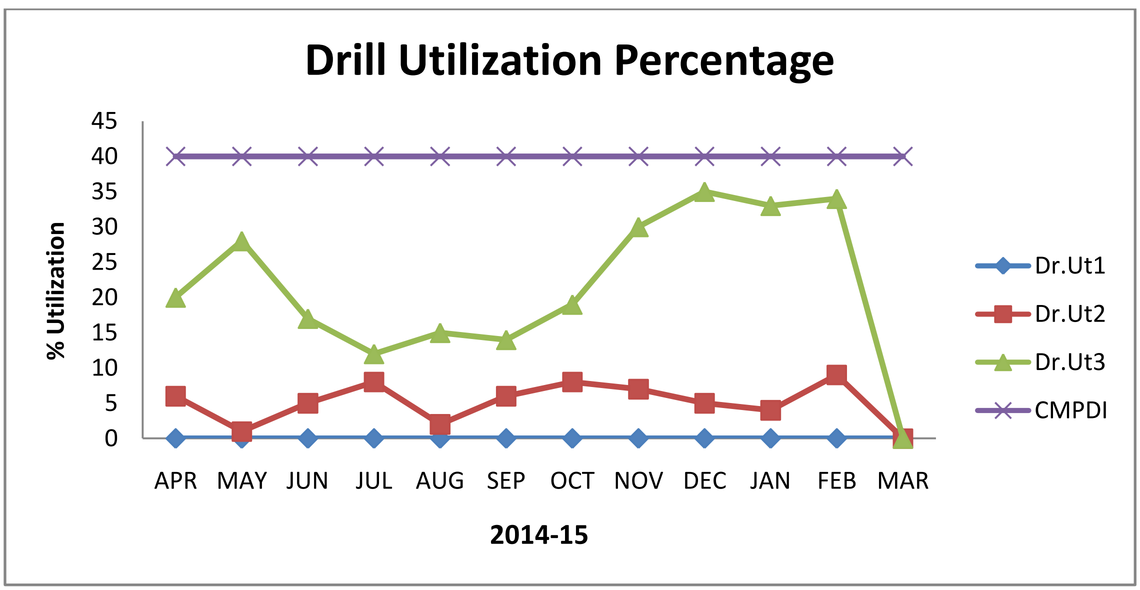

Fig.3.8 Utilization Percentage of Drill

From the fig.3.1 we can see that the availability percentage of all the shovel except CK 300 shovel model is lower than the CMPDI norm because of repair work , rack pinion problem of the shovels **[4]**.

From the fig.3.5 we also see that the percentage availability for the dozer is also low due to the failure of the final transmission & engine. The percentage of utilization of all the HEMMs from fig.3.2, fig.3.4 , fig.3.6 , fig.3.8 we see that they are below their respective CMPDI norm due to more numbers of idle hours because of unpredicted rain **[4]**.

3.4 CALCULATION OF OEE FOR SHOVELS OF GOPINATHPUR MINE (2014-15).

The overall equipment effectiveness (OEE) can be calculated using the formula

$$\text{OEE}=\text{Avaiability} \times \text{Performance} \times \text{Quality} \quad (7)$$

TABLE.3.7 OEE for shovel models

Shovel Model	Total Hours	Unscheduled Maintenance Hours	Maintenance Hours	Idle Hours	Quality	Availability	Performance	OEE
H350EX	718	204	53	234	0.856	0.624	0.32	0.18
H55N	718	561	10	108	0.93	0.21	0.05	0.01
EX 300	718	110	19	191	0.81	0.68	0.21	0.12
CK 300	718	57	54	304	0.89	0.85	0.43	0.33

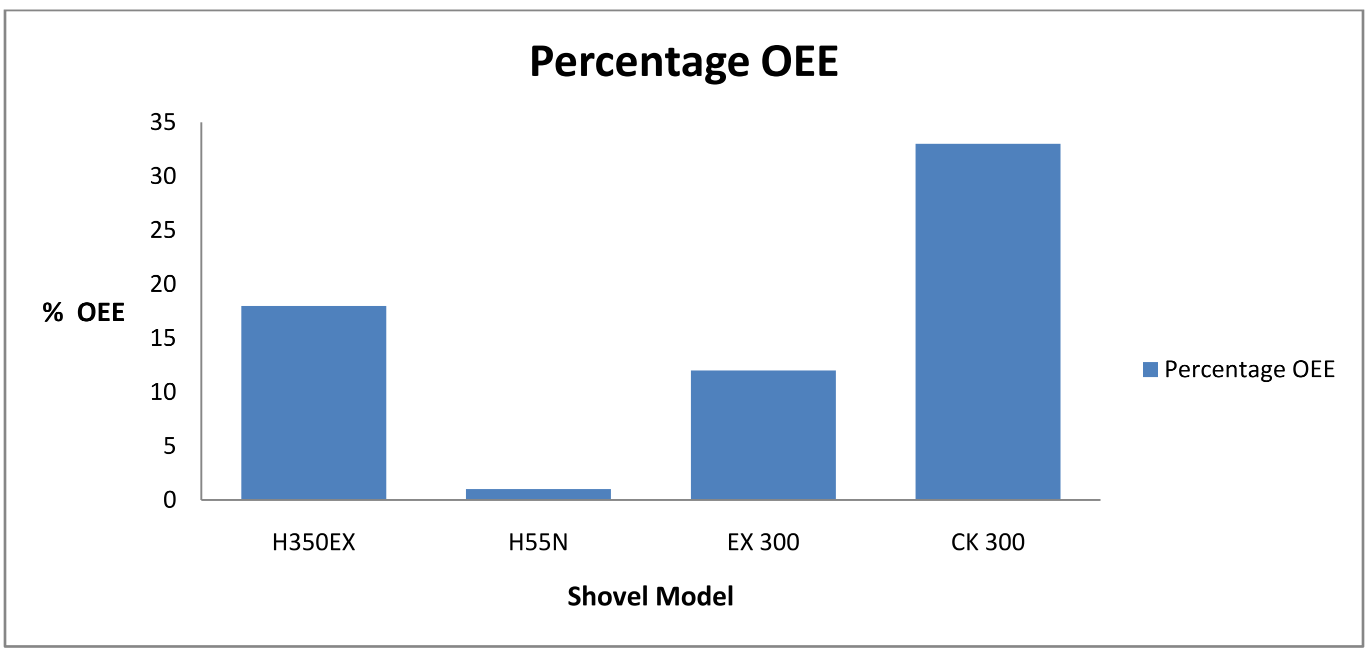

Fig.3.9 Percentage OEE of shovel models (2014-15)

3.5 PERFORMANCE OF THE HEMMS IN JEENAGORA MINE (2014-15)

TABLE.3.8: Working Hours (2014-15)

Machine	Model		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Drill	C 650		403	430	341	543	387	344	432	434	479	381	362	422	4524
	160D(RNH)		520	443	409	483	415	465	482	399	60	79	475	439	4669
Dozer	D355A	495	427	593	464	586	445	485	510	525	157	378	531	508	5609
		1150	598	538	511	372	234	500	431	572	567	445	456	513	5737
		3406	523	534	566	447	546	503	489	429	501	533	320	431	5822
Dumper	BH60M	1710	521	501	467	499	530	589	576	555	476	500	443	513	6170
		2300	534	512	477	529	454	543	597	503	451	521	444	544	6109
	BH50M1	170	514	573	532	510	399	430	519	521	474	449	342	522	5785
		855	534	521	478	492	436	335	522	510	500	466	539	446	5779
		488	519	593	377	448	529	457	456	509	441	530	398	537	5794
Shovel	EKG 5.0		531	534	459	511	539	452	342	522	425	488	549	500	5852
	EX300-LC		303	433	444	481	432	531	398	567	556	529	531	518	5823
	90 CK		413	423	525	439	443	386	366	375	455	521	430	547	5274

TABLE.3.9: Maintenance Hours (2014-15)

Machine	Model		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Drill	C 650		32	12	17	23	29	26	20	11	52	10	43	26	301
	160D(RNH)		11	25	37	23	47	43	29	41	8	21	33	22	340
Dozer	D355A	495	45	48	51	22	19	38	21	25	33	36	32	28	398
		1150	32	20	39	35	45	52	50	15	24	18	19	23	372
		3406	25	28	12	16	16	27	56	35	32	44	48	39	378
Dumper	BH60M	1710	55	41	49	33	21	11	17	15	32	29	27	21	351
		2300	37	36	33	44	38	47	20	15	24	25	14	18	351
	BH50M1	170	19	21	31	42	44	36	45	51	25	18	39	53	424
		855	55	43	33	21	28	59	43	54	38	42	24	29	433
		488	43	25	58	22	19	12	31	23	34	47	55	23	382
Shovel	EKG 5.0		23	10	44	29	15	51	44	18	34	31	45	32	370
	EX300-LC		61	21	29	33	41	24	35	45	51	33	22	11	406
	90 CK		13	32	44	53	37	56	43	42	35	52	34	23	466

TABLE.3.10: Breakdown Hours (2014-15)

Machine	Model		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Drill	C 650		232	16	102	27	99	67	134	23	49	210	25	16	1000
	160D(RNH)		103	34	48	25	129	27	18	152	538	498	36	132	1073
Dozer	D355A	495	12	3	15	29	129	17	3	34	321	49	64	26	702
		1150	14	37	6	132	368	29	1	18	4	33	46	78	766
		3406	5	24	2	35	18	21	6	10	19	8	121	90	359
Dumper	BH60M	1710	25	8	11	39	7	2	17	44	12	37	54	9	265
		2300	38	22	6	21	34	8	9	3	11	32	56	44	246
	BH50M1	170	4	35	9	4	48	59	32	23	5	76	6	39	340
		855	28	33	21	5	8	9	13	22	32	18	20	10	191
		488	56	23	33	45	24	9	4	11	30	19	17	21	292
Shovel	EKG 5.0		29	18	22	23	76	67	36	49	2	3	8	3	345
	EX300-LC		86	36	71	6	9	10	13	27	29	35	11	27	360
	90 CK		38	72	32	37	61	36	29	83	8	4	3	14	417

TABLE.3.11: Idle Hours (2014-15)

Machine	Model		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Drill	C 650		1	212	210	77	150	233	84	202	90	69	240	206	1774
	160D(RNH)		127	168	176	139	79	135	141	78	64	72	126	77	1382
Dozer	D355A	495	186	26	140	33	7	130	136	86	159	207	43	108	1261
		1150	26	75	114	131	23	89	188	65	75	174	149	61	1170
		3406	117	84	90	172	90	122	119	196	118	85	181	110	1484
Dumper	BH60M	1710	69	120	143	99	112	68	32	97	150	104	146	127	1267
		2300	61	100	133	76	144	72	44	113	184	92	156	64	1239
	BH50M1	170	133	41	98	114	179	145	74	75	189	127	83	56	1314
		855	53	93	138	153	198	67	92	115	100	144	87	185	1425
		488	52	29	202	155	98	192	179	127	165	74	216	89	1578
Shovel	EKG 5.0		87	108	145	107	40	100	48	81	209	148	68	135	1276
	EX300-LC		220	180	126	150	188	125	224	31	50	73	106	114	1587
	90 CK		206	143	69	141	129	192	232	170	172	93	203	86	1775

TABLE.3.12: Percentage Availability (2014-15)

Machine	Model		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Drill	C 650		61	96	82	93	81	86	77	95	85	67	90	94	83
	160D(RNH)		85	91	83	93	74	89	93	71	19	23	90	77	82
Dozer	D355A	495	92	92	90	92	74	92	96	91	47	87	86	92	86
		1150	93	92	92	77	38	88	92	95	96	92	90	85	86
		3406	96	92	98	92	95	93	91	92	92	92	75	81	91
Dumper	BH60M	1710	88	93	91	89	96	97	95	93	93	90	88	96	92
		2300	89	91	94	90	84	92	96	97	95	92	90	91	93
	BH50M1	170	97	92	94	93	86	86	88	89	96	86	90	86	90
		855	88	89	92	96	95	86	92	89	90	91	91	94	92
		488	85	93	86	90	94	97	95	95	90	90	90	93	92
Shovel	EKG 5.0		92	96	90	92	89	82	83	90	95	95	92	95	91
	EX300-LC		78	91	85	94	93	95	93	89	88	90	95	94	91
	90 CK		92	84	87	87	85	86	89	81	94	92	95	95	89

TABLE.3.13: Percentage Utilization (2014-15)

Machine	Model		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Drill	C 650		60	64	51	81	58	51	65	65	72	57	54	63	50
	160D(RNH)		66	66	57	72	62	69	72	60	89	12	71	66	63
Dozer	D355A	495	64	89	69	88	73	72	76	78	23	56	71	76	70
		1150	89	80	75	57	35	75	64	85	85	65	68	76	71
		3406	78	80	85	68	82	75	73	63	63	79	48	64	73
Dumper	BH60M	1710	78	75	70	74	79	86	90	79	79	75	66	77	77
		2300	80	76	74	79	63	81	89	80	80	78	66	81	77
	BH50M1	170	77	86	79	76	59	64	77	78	78	67	78	78	73
		855	80	75	71	73	65	76	78	72	72	70	78	66	74
		488	77	89	56	67	79	68	68	76	76	79	58	78	72
Shovel	EKG 5.0		79	80	68	76	83	67	76	78	78	73	82	75	75
	EX300-LC		54	64	66	72	65	76	60	84	84	79	73	77	72
	90 CK		61	63	77	66	68	57	54	55	55	78	65	74	67

3.6 PERCENTAGE AVAILABILITY AND PERCENTAGE UTILIZATION GRAPH OF THE HEMMS IN JEENAGORA MINE (2014-15)

- **For Shovels**

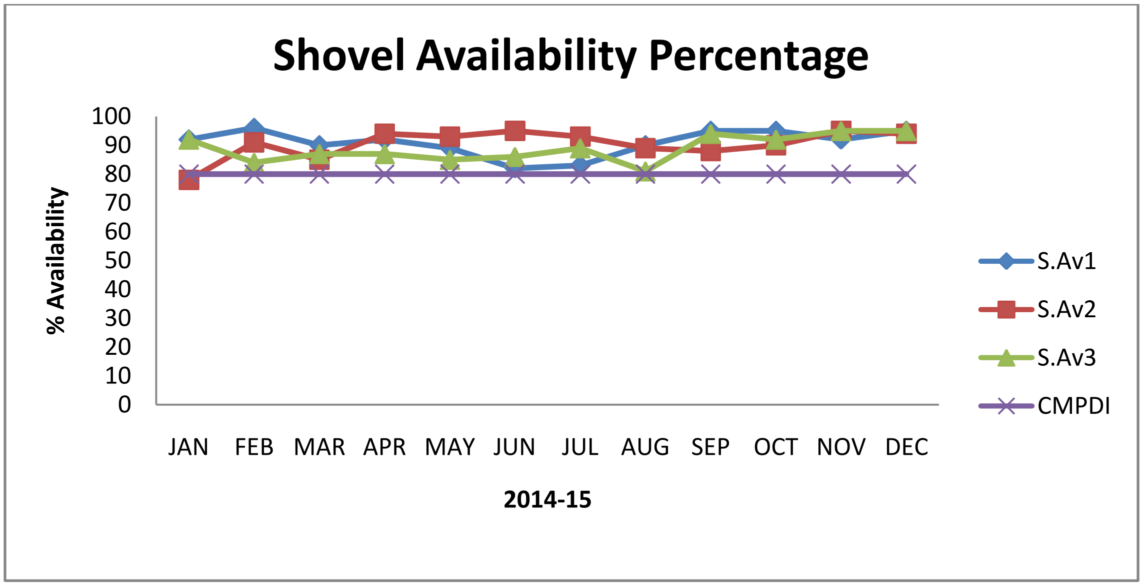

Fig.3.10 Availability Percentage of Shovel

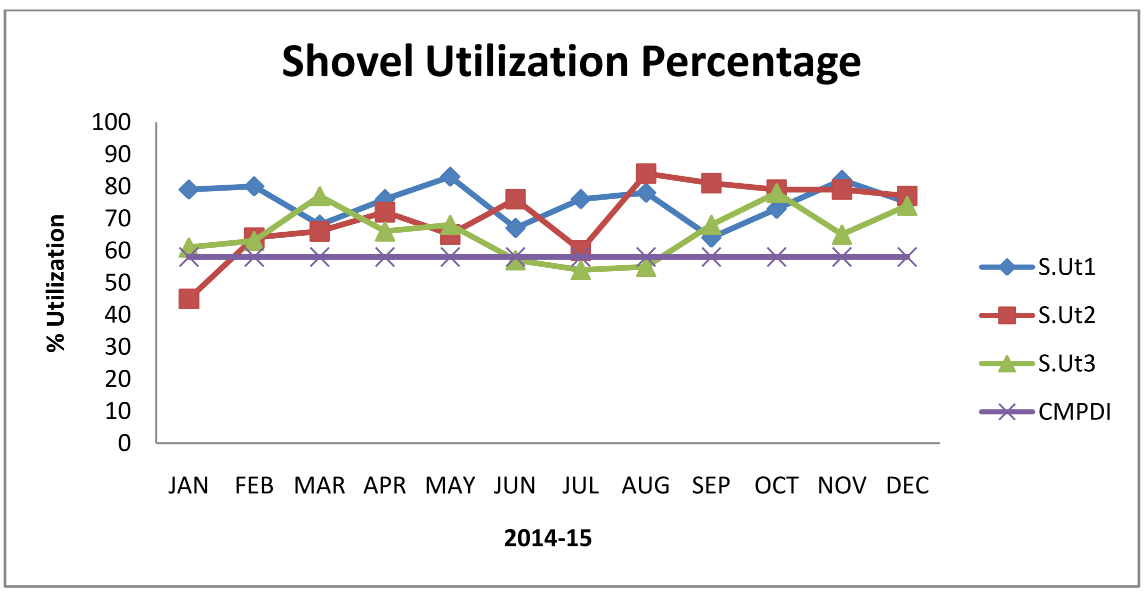

Fig.3.11 Utilization Percentage of Shovel

➢ **For Dumper**

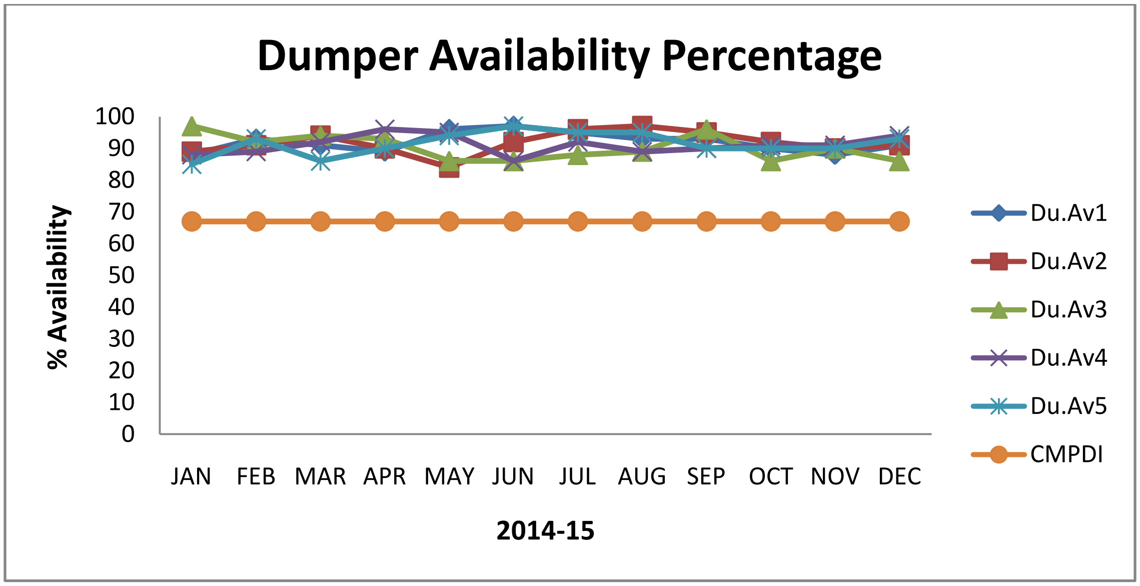

Fig.3.12 Availability percentage Dumper

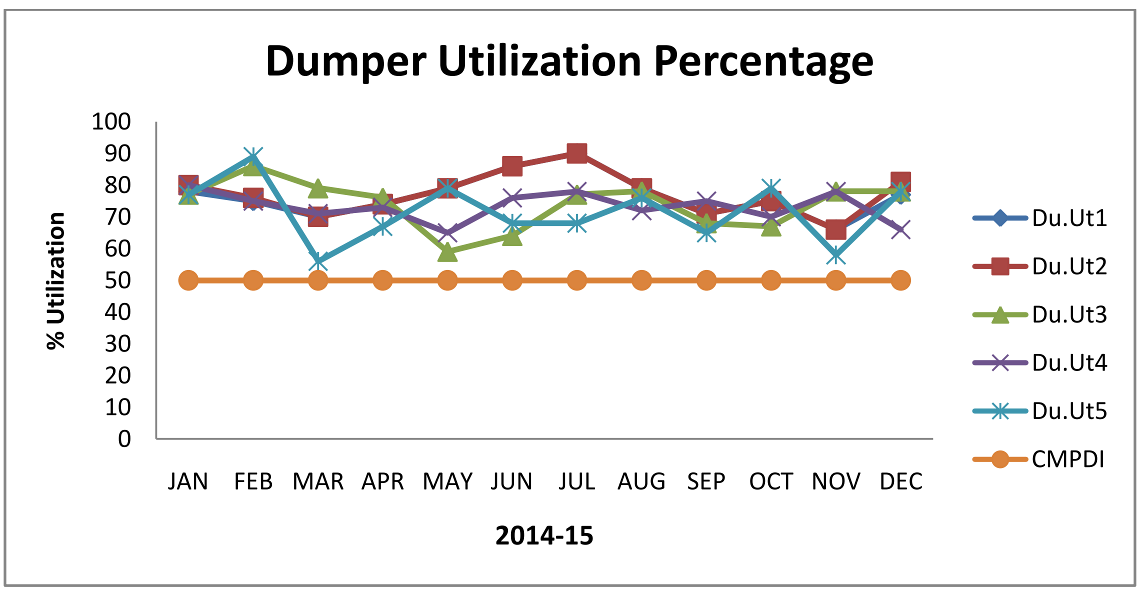

Fig.3.13 Utilization Percentage of Dumper

➢ **For Dozer**

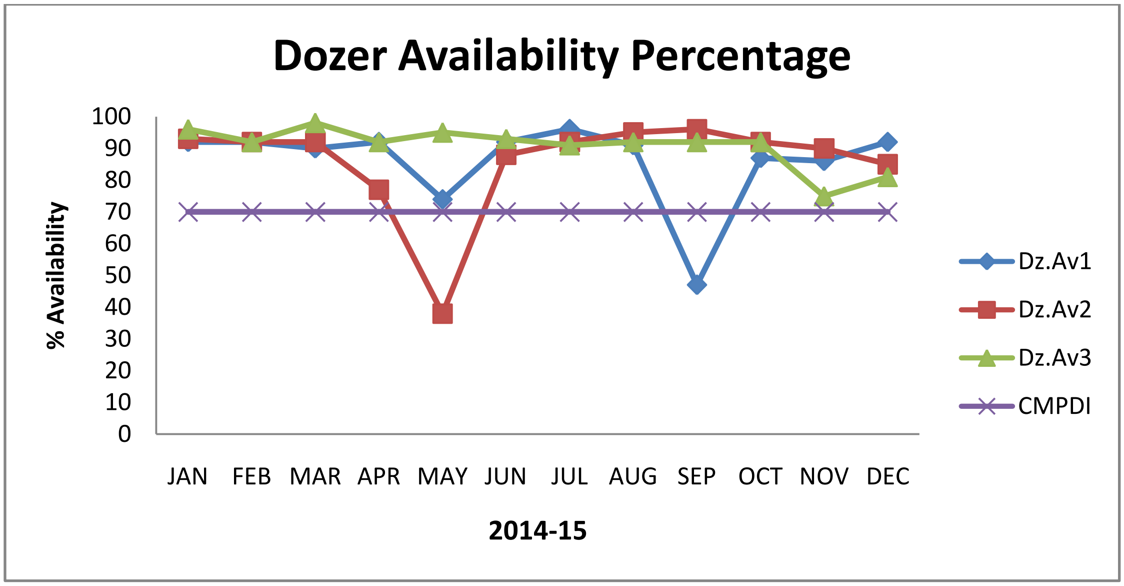

Fig.3.14 Availability Percentage of Dozer

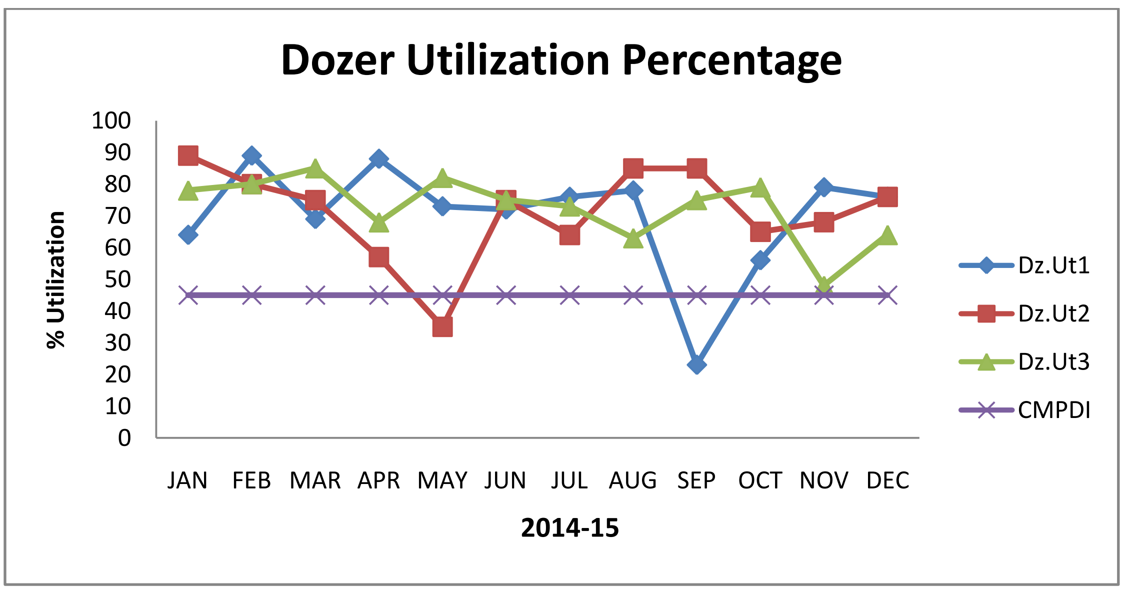

Fig.3.15 Utilization Percentage of Dozer

- **For Drills**

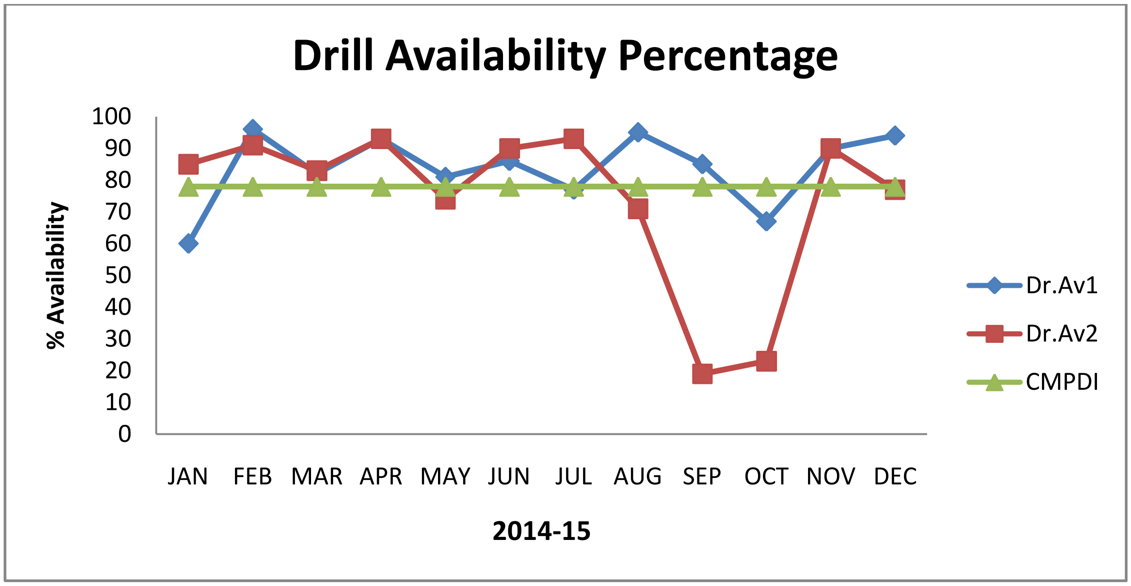

Fig.3.16 Availability Percentage of Drill

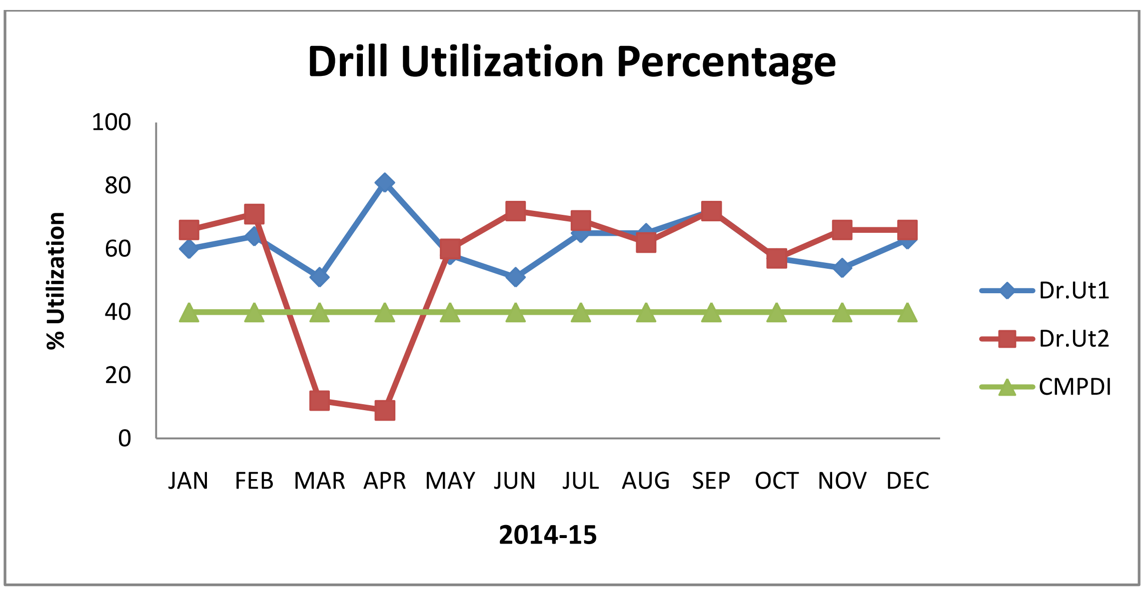

Fig.3.17 Utilization Percentage of Drill

The percentage availability of the shovel model EX-300 LC is below CMPDI norm i.e.80 % in the month of January due to more number of breakdown hours because of bucket repairing, dipper stick problem and percentage utilization is also below CMPDI norm of 58% due to more idle hours because of non-seasonal rain **[4]**.

The availability Percentage and utilization Percentage of the dozer model D355A having serial no.(1150,495) is low in the month of May & September as compared to CMPDI norm 70 % & 45 %due high breakdown hours and idle hours of the two dozer models **[4]**.

The Percentage availability of the drill in the month September, October is below CMPDI norm of 78% due to breakdown of the hydraulic pump **[4].**

3.7 CALCULATION OF OEE FOR SHOVELS OF JEENAGORA MINE (2014-15).

Table.3.14: OEE for shovel models

Shovel Model	**Total Hours**	**Non-schedule Hours**	**Maintenance Hours**	**Unscheduled Maintenance Hours**	**Idle Hours**	**Quality**	**Availability**	**Performance**	**OEE**
EXG 5.0	720	70	32	3	135	0.875	0.854	0.67	0.50
EX300-LC	720	70	11	27	114	0.75	0.85	0.69	0.44
90 CK	720	70	23	14	86	0.93	0.851	0.73	0.58

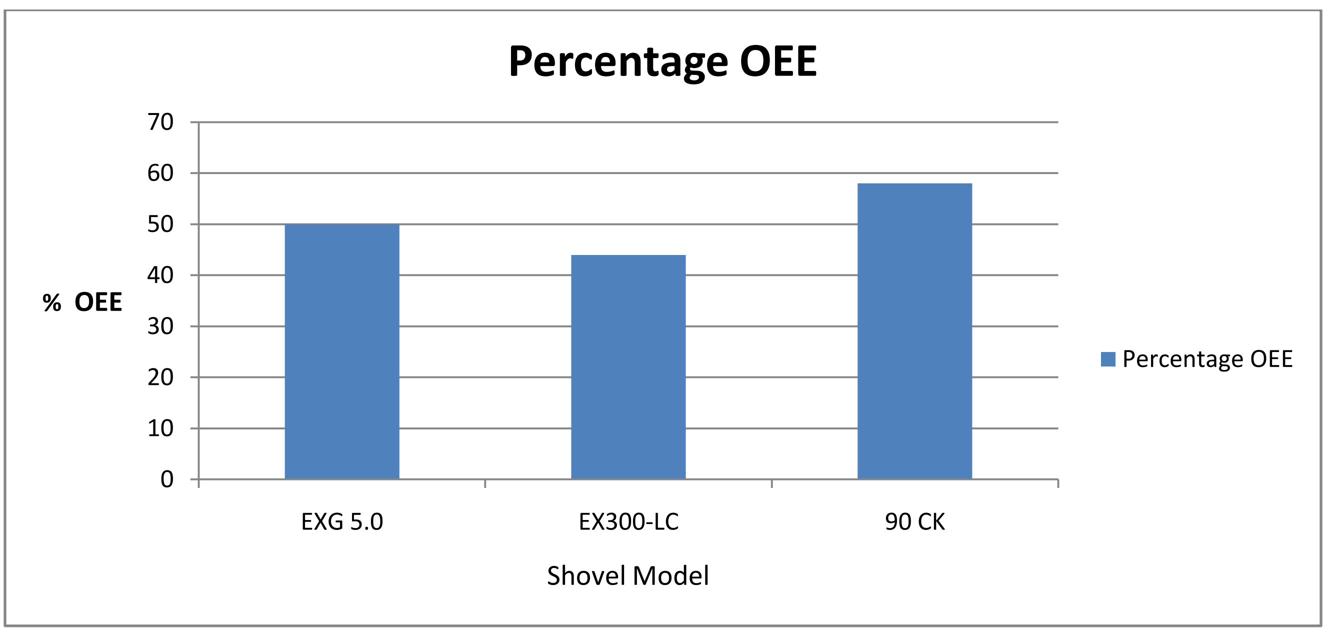

Fig.3.18 Percentage OEE of shovel Models (2014-15)

3.8 COMPARISON OF SHOVEL PERFORMANCE AT GOPINATHPUR MINE, ECL AND JEENAGORA MINE, BCCL (2014-15).

Table.3.15: Percentage Availability

Mine	**Month below norm**	**Maximum Availability Percentage**	**Minimum Availability Percentage**	**CMPDI Norm**	**Remark**
Gopinathpur Mine ,ECL	All the months except model CK300	91	0	80	Availability percentage of Jeenagora Mine, BCCL, is better as compared to Gopinathpur Mine, ECL for 2014-15
Jeenagora Mine ,BCCL	Jan	96	78		

Table.3.16: Percentage Utilization

Mine	**Month below norm**	**Maximum Utilization Percentage**	**Minimum Utilization Percentage**	**CMPDI Norm**	**Remark**
Gopinathpur Mine ,ECL	Almost whole year	66	0	58	Percentage utilization of the shovel from Jeenagora Mine is also better than Gopinathpur
Jeenagora Mine ,BCCL	Jan, Jun, Jul, Aug	82	54		

3.9 COMPARISON OF PERFORMANCE OF DUMPER GOPINATHPUR MINE, ECL AND JEENAGORA MINE, BCCL (2014-15).

Table.3.17: Percentage Availability

Mine	**Month below norm**	**Maximum Availability Percentage**	**Minimum Availability Percentage**	**CMPDI Norm**	**Remark**
Gopinathpur Mine ,ECL	Oct, Nov, Dec Mar	99	0	67	Percentage Availability of the dumper from Jeenagora Mine is far better than Gopinathpur mine
Jeenagora Mine ,BCCL	None	97	78		

Table.3.18: Percentage Utilization

Mine	**Month below norm**	**Maximum Utilization Percentage**	**Minimum Utilization Percentage**	**CMPDI Norm**	**Remark**
Gopinathpur Mine ,ECL	Almost whole year	52	0	50	Percentage utilization of the dumpers from Jeenagora Mine is fairly above CMPDI norm
Jeenagora Mine ,BCCL	None	83	54		

3.10 COMPARISON OF PERFORMANCE OF DOZERS GOPINATHPUR MINE, ECL AND JEENAGORA MINE (2014-15).

Table.3.19: Percentage Availability

Mine	Month below norm	Maximum Availability Percentage	Minimum Availability Percentage	CMPDI Norm	Remark
Gopinathpur Mine ,ECL	Jan, Mar	98	0	70	Performance of the dumpers from Jeenagora Mine & Gopinathpur Mine is are good except one model B-155 (847)
Jeenagora Mine ,BCCL	May, Sep	98	38		

Table.3.20: Percentage Utilization

Mine	Month below norm	Maximum Utilization Percentage	Minimum Utilization Percentage	CMPDI Norm	Remark
Gopinathpur Mine ,ECL	Whole year	38	0	45	Percentage utilization of the dozers from Jeenagora Mine is fairly above CMPDI norm than Gopinathpur Mine
Jeenagora Mine ,BCCL	May, Sep	89	23		

3.11 COMPARISON OF PERFORMANCE OF DRILLS GOPINATHPUR MINE, ECL AND JEENAGORA MINE BCCL (2014-15).

Table.3.21: Percentage Availability

Mine	**Month below norm**	**Maximum Availability Percentage**	**Minimum Availability Percentage**	**CMPDI Norm**	**Remark**
Gopinathpur Mine ,ECL	Jan, Mar, Apr, May, Jun, Oct	97	0	78	Performance of the drills from Jeenagora Mine is better than Gopinathpur Mine
Jeenagora Mine ,BCCL	Jan, Aug, Sep, Oct	96	19		

Table.3.22: Percentage Utilization

Mine	**Month below norm**	**Maximum Utilization Percentage**	**Minimum Utilization Percentage**	**CMPDI Norm**	**Remark**
Gopinathpur Mine ,ECL	Whole year	35	0	40	Performance of the drills from Jeenagora Mine is far better than Gopinathpur Mine
Jeenagora Mine ,BCCL	Mar, Apr	81	8.9		

3.12 COMPARISON OF OEE OF THE SHOVEL AT GOPINATHPUR MINE, ECL AND JEENAGORA MINE BCCL (2014-15).

Table.3.23 Comparison of OEE of Shovels

Shovel Models	**OEE**	**Mines**	**Remarks**
H 350 EX	0.18	Gopinathpur Mine ,ECL	Low OEE of Gopinathpur Mine indicates that Ineffectiveness of the equipment and more time for the repairing work as equipment of that mine is breakdown for most of the time
H 55 N	0.01		
EX 300	0.12		
CK 300	0.3		
EKG 5.0	0.50	Jeenagora Mine, BCCL	
EX 300-LC	0.44		
90 CK	0.58		

Chapter 4
CONCLUSION

Percentage availability and percentage utilization of shovel, dumper, dozer, drill were calculated on the basis of working hours, breakdown hours, maintenance hours, idle hours collected from Gopinathpur Mine, Mugma Area, ECL and Jeenagora Mine, Lodna Area, BCCL and it is concluded that the percentage availability and utilization of the HEMMs i.e. (shovel, dumper, dozer, drill) of the Jeenagora Mine is better than the Gopinathpur because the equipments were remain breakdown for most of the time.

Also ,OEE (Overall Equipment Effectiveness) of the shovel was calculated.OEE of the four shovel with model EX 350, H55N, EX 300, CK 300 of Gopinathpur Mine were found to be 0.18, 0.01, 0.12, 0.33 respectively and OEE of the three shovel with model EKG 5.0, EX 300- LC, 90 CK of Jeenagora Mine were found to be 0.50, 0.44, 0.58 respectively which indicates that the effectiveness of the equipment of Jeenagora Mine was better than Gopinathpur Mine in the year 2014-15.

Low OEE indicates that the equipments are not properly used and also indicates low productivity of the equipments .The productivity of the equipments that are used can be improve or increase if the breakdown hours, idle hours are reduce and give proper maintenance.

Utilization factor is very important for the performance analysis of the mining equipments as it not only consider downtime due to the breakdown of equipment but also the idle time .so this factor helps to improve the low production and poor OEE.

Chapter 5

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